Pedobiologia 27, 299—311 (1984)

Center for the Study of Ornamental Plant Breeding
Section: Entomology and Nematology
Faculty of Agricultural Sciences
State University of Gent (Belgium)

The influence of some acids, bases and salts on the mite and Collembola population of a pine litter substrate *)

A. HEUNGENS & E. VAN DAELE

With 2 figures

(Accepted: 84-05-10)

1. Introduction

Some physico-chemical factors of the plant substrate such as acidity (pH) and salt concentration (conductivity), affect plant development to a large degree.

The knowledge of their influence on the soil fauna and flora is insufficient. When the soil contains a large organic fraction, for example, as in pine litter, the influence of the physico-chemical factors on the plant development is still more important because the wealth of soil organisms in such substrates depends largely on the decomposition by the fauna and microflora. In this case the physical characteristics of the substrate also are affected.

As such the physico-chemical factors can produce interactions between substrate — fauna and microflora — plant development. The influence of the conductivity (salt concentration) on the fauna of a pine litter substrate has already been studied (HEUNGENS 1980; HEUNGENS & VAN DAELE 1981). In this study the effect on the mite and Collembola populations with changes in the substrate acidity (pH) is considered.

Compounds increasing the pH have a pronounced effect on the saprophagous nematodes; for examples with KOH their population could be increased more than ten times in a short period (HEUNGENS 1981).

By adding some compounds the acidity of the substrate can easily be changed. Tests were carried out with acids, bases and salts. Because the conductivity is also affected by these compounds and that each can present a specific action, it appears rather difficult to establish precisely what is the primary effect.

2. Material and methods

At the beginning of December 1980 a test was carried out with a fresh pine litter substrate (*Pinus silvestris*). The pH was between 4.2 and 4.7 with a mean of 4.4 and a standard deviation of 0.15 (n = 8). This substrate was put in plastic containers (10 l substrate per container) and treated with acids, bases and with both (= salts).

We obtained seven modalities with the following doses (per liter substrate):

(1) control;
(2) citric acid (6 g);
(3) nitric acid (6.5 ml 1 N HNO_3)
(4) potassium nitrate (3 g);
(5) calcium citrate [1.6 g $Ca(OH)_2$ + 4 g citric acid];
(6) potassium hydroxide (3 g);
(7) calcium hydroxide (4 g).

*) Research subsidized by the Institute for the Encouragement of Scientific Research in Industry and Agriculture (IWONL)

Table 1. Progress of pH and conductivity ($\mu S\ cm^{-1}$) in the test substrates*)

After		1/2 month	1	1 1/2	2	3	4 1/2	6 months
Control	pH	4.4	4.4	4.4	4.3	4.1	4.4	4.5
	$\mu S\ cm^{-1}$	95	95	95	120	185	160	200
Nitric	pH	3.4	3.4	3.4	3.6	3.6	3.7	3.8
acid	$\mu S\ cm^{-1}$	350	375	380	355	370	360	410
Citric	pH	3.3	3.6	3.9	3.9	3.8	4.2	4.3
acid	$\mu S\ cm^{-1}$	250	175	120	145	145	150	155
Potassium-	pH	3.9	4.0	4.0	4.1	4.1	4.2	4.4
nitrate	»S cm^{-1}	1,035	1,030	990	1,080	1,050	1,055	1,200
Calcium-	pH	5.7	5.6	6.6	5.2	5.0	4.9	4.8
citrate	$\mu S\ cm^{-1}$	185	145	90	170	250	275	350
Calcium-	pH	6.9	7.0	7.0	5.6	6.6	6.4	6.7
hydroxide	$\mu S\ cm^{-1}$	470	360	235	355	475	335	340
Potassium-	pH	7.3	7.1	7.0	6.7	6.4	6.4	5.6
hydroxide	$\mu S\ cm^{-1}$	560	430	500	570	680	580	950

*) mean of 4 observations

The test was carried out with four replicates of 10 l substrate over the following temperature ranges: Dec. 4—9°C, Jan. 2—8 °C, Feb. 2—12 °C, March 6—16 °C, April 5—18 °C and May 12 to 21 °C. The humidity was adjusted weekly by means of rainwater. The progress of pH and conductivity (Table 1) was achieved by the method of HEUNGENS *et al.* (1975).

It can be concluded from Table 1 that KNO_3 also increases the acidity and Ca-citrate the alkalinity. Citric acid was probably converted enzymatically by bacteria to the end of the test. By building up K_2CO_3, potassium hydroxide showed a more moderate pH after 6 months. The measurements proved that the buffer capacity of the litter was maintained.

The Collembola and mites were sampled after 6 weeks, 3 and 6 months. The samples had a volume of 100 ml and the organisms were collected by means of Tullgren funnels. The total number of samples was 84 (7 treatments × 3 periods × 4 repetitions).

3. Results

3.1. Collembola

The samples contained 5,310 Collembola or 63 per 100 ml. *Proisotoma minuta* was pronouncedly dominant (90.5%) followed by *Tullbergia krausbaueri* with 6.12% and *Isotoma notabilis* 1.7%. Eleven species were observed. These data are summarized in Table 2.

For the best represented Collembola species the analysis of variance was calculated on the transformed number per 100 ml substrate (Table 3.).

Table 2. Total number of Collembola and relative population densities

	Total	%
Neanura muscorum (TEMPLETON)	17	0.32
Friesea mirabilis (TULLBERG)	4	0.08
Anurida pygmaea (BÖRNER)	10	0.19
Tullbergia krausbaueri (BÖRNER)	325	6.12
Proisotoma minuta (TULLBERG)	4,805	90.49
Proisotoma minima (ABSOLON)	1	0.02
Isotoma sensibilis (TULLBERG)	10	0.19
Isotoma notabilis SCHÄFFER	91	1.71
Neelus minimus WILLEM	40	0.75
Sminthurinus sp.	4	0.08
Sminthurides sp.	3	0.06
Total	**5,310**	**100.01**

Table 3. The calculated mean squares (M. S.) and the F-values after analysis of variance ($\sqrt[3]{x+0.125}$-transformation) on the Collembola numbers

Source of variation	d.f.	*Tullbergia krausbaueri*		*Isotoma notabilis*		*Proisotoma minuta*		F-table	
		M.S.	F	M.S.	F	M.S.	F	0.05	0.01
Total	83	0.5063	—	0.2455	—	2.9750	—	—	—
Treat-ments *(T)*	6	0.5553	2.28 (*)	0.5215	4.54 (*)	11.3864	19.11 (**)	2.25	3.12
Period (time) *(P)*	2	10.1311	41.52 (**)	2.2141	19.28 (**)	15.7354	26.40 (**)	3.15	4.98
$T \times P$	12	0.2547	1.04	0.4658	4.06 (**)	9.1326	15.42 (**)	1.92	2.50
Residual Error	63	0.2440	—	0.1148	—	0.5959	—	—	—

(*) (**) significant difference for the confidence levels 95 % and 99 %.

Transformation is necessary to obtain normally distributed data. Although a log-transformation is usual, we often obtain better results with a $\sqrt[3]{x}$-transformation.

From the data given in Table 3 it can be concluded that the effect of the sampling period on the density of the Collembola population was more pronounced than the effect of the treatments. In general time (season)-influence in arthropods is so striking that population fluctuations are a common phenomenon. As such interactions ($T \times P$) will also appear, but giving the high number of discussed collembola and mites it is practically excluded to go further into this matter.

For the 3 Collembola species the changes in population density according to the period are given in Table 4.

At the end of the test, *Proisotoma minuta* and *Isotoma notabilis* showed a pronounced increase in numbers; however, *Tullbergia krausbauri* practically disappeared.

The aim of the test was to determine in the first instance the influence of acids, bases and salts on the population densities. In Table 5 are given the transformed means per 100 ml substrate according to the treatments and also the least significant differences.

A reliable estimation of the number per liter according to retransformation is given in Table 6.

Fig. 1 shows graphically the same results as Table 6.

The results prove that potassium nitrate at 3 g l^{-1} pine litter is very toxic to Collembola; indeed, the population decreases to less than 13 % of the control. Nitric acid also was harmful to the three most important species.

Most striking is the very significant increase of the *Proisotoma minuta* population after application of KOH. An increase of 400 % could best be attributed to the presence of more prey. It could be nematodes in the case of *Proisotoma minuta*, which would confirm the results with nematodes (HEUNGENS 1981).

Table 4. Distribution of the Collembola population according to sampling period

	After 6 weeks	After 3 months	After 6 months	**Total**
Tullbergia krausbaueri	229	88	8	**325**
Proisotoma minuta	724	297	3,784	**4,805**
Isotoma notabilis	8	5	78	**91**
	961	390	3,870	**5,221**

Table 5. Transformed mean (*) of the Collembola number per 100 ml substrate according to the treatments

Treatments	*Tullbergia krausbaueri*	*Proisotoma minuta*	*Isotoma notabilis*
Control	1.576	2.822	0.892
Nitric acid	1.079 (—)	1.933 (— —)	0.566 (—)
Citric acid	1.280	2.700	0.566 (—)
Potassium nitrate	0.933 (— —)	1.408 (— —)	0.500 (— —)
Calcium citrate	1.220	3.151	0.879
Calcium hydroxide	1.438	3.042	1.052
Potassium hydroxide	1.181	4.478 (+ +)	0.802
l.s.d. (0.05)	0.403	0.630	0.277
(0.01)	0.536	0.838	0.368

(+) (—) (+ +) (— —) significant more or less than the control for p = 0.05 and p = 0.01.

(*) $(1/n \sum \sqrt[3]{x + 0.125})$ n = 12 (3 periods × 4 repetitions).

Table 6. Average number (*) per liter substrate according to the treatments.

Treatments	*Tullbergia krausbaueri*	*Proisotoma minuta*	*Isotoma notabilis*
Control	37.9	223.5	5.9
Nitric acid	11.3 (—)	71.0 (— —)	0.6 (—)
Citric acid	19.7	195.6	0.6 (—)
Potassium nitrate	6.9 (— —)	26.7 (— —)	0.0 (— —)
Calcium citrate	16.9	311.6	5.5
Calcium hydroxide	28.5	280.3	10.4
Potassium hydroxide	15.2	896.7 (+ +)	3.9

(*) after retransformation and biometric calculation. Period: mean between 6 weeks, 3 and 6 months after treatment
(+) (—) (+ +) (— —) significant more or less than the control for p = 0.05 and p = 0.01.

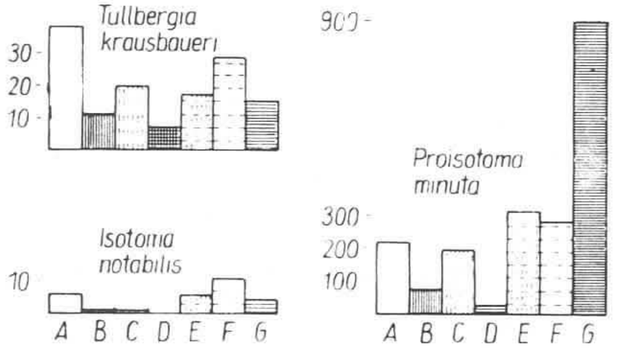

Fig. 1. The average number of the collembola per liter substrate according to the treatments.

A = Control
B = Nitric acid
C = Citric acid
D = Potassium nitrate
E = Calcium citrate
F = Calcium hydroxide
G = Potassium hydroxide

Table 7. Total number of mites and relative population densities

	Total	%
Gamasina	1,072	4.27
Alliphis siculus (Oudemans)	131	0.52
Pachylaelaps pectinifer (G. & R. Canestrini)	1	—
Hypoaspis aculeifer (Canestrini)	10	0.04
Hypoaspis claviger (Berlese)	6	0.02
Proctolaelaps sp.	7	0.03
Zerconopsis remiger (Kramer)	19	0.08
Arctoseius cetratus (Sellnick)	6	0.02
Zercon triangularis C. L. Koch	1	—
Rhodacarus coronatus Berlese	11	0.04
Holoparasitus excipuliger (Berlese)	1	—
Pergamasus septentrionalis (Oudemans)	10	0.04
Pergamasus lapponicus Trägårdh	21	0.08
Pergamasus robustus (Oudemans)	16	0.06
Pergamasus vagabundus Karg	510	2.03
Pergamasus sp. nymphs	292	1.16
Veigaia nemorensis (C. L. Koch)	30	0.12
Uropodina	153	0.61
Uropoda minima Kramer	137	0.55
Uroseius cylindricus (Berlese)	3	0.01
Uropodina juveniles, *Gen. spec.*	13	0.05
Prostigmata	350	1.39
Cocceupodes sp.	1	—
Eupodes sp.	37	0.15
Rhagidia pratensis (C. L. Koch)	3	0.01
Ereynetes insularis Willmann	10	0.04
Tydeus kochi Oudemans	20	0.08
Coccotydeus frequens Grandjean	1	—
Bimichaelia diadema Grandjean	245	0.98
Pachygnathus villosus Dugés	2	0.01
Stigmaeus eutrichus Berlese	14	0.06
Eustigmaeus rhodomela (Koch)	2	0.01
Paralorryia mali (Oudemans)	8	0.03
Nanorchestes arboriger (Berlese)	1	—
Tetranychus sp.	6	0.02
Tarsonemini	597	2.38
Scutacaridae (1)	462	1.84
Pyemotidae (2)	63	0.25
Tarsonemus spp.	72	0.29
Acaridiae	1,648	6.56
Tyrophagus sp.	6	0.02
Caloglyphus sp.	2	0.01
Schwiebea spp.	964	3.84
Histiostoma spp.	527	2.10
Wichmannia spinifera (Michael)	120	0.48
Acaridiae juveniles, *Gen. spec.*	29	0.12
Oribatei	21,307	84.80
Steganacarus striculus (C. L. Koch)	6,047	24.07
Rhysotritia duplicata (Grandjean)	679	2.70
Microtritia minima (Barlese)	4,763	18.96
Phthiracaridae juveniles	221	0.88
Hypochthonius rufulus C. L. Koch	3	0.01
Hypochthoniella minutissima Michael	181	0.72
Brachychthonius berlesei Willmann	6	0.02
Liochthonius perpusillus Berlese	66	0.26
Liochthonius hystricinus (Forsslund)	7	0.03
Nothrus silvestris Nicolet	1,047	4.17
Platynothrus peltifer (C. L. Koch)	128	0.51

(1) *Scutacarus sp.* + *Imparipes sp.*
(2) *Pseudopygmephorus sp.* + *Siteropsis arenae* (Müller)

(Continued Table 7)

	Total	%
Camisia segnis (HERMANN)	82	0.33
Camisia spinifer (C. L. KOCH)	45	0.18
Trhypochthonius sp.	1	—
Cepheus cepheiformis (NICOLET)	1	—
Carabodes marginatus (MICHAEL)	59	0.23
Odontocepheus elongatus (MICHAEL)	1	—
Tectocepheus velatus adult (MICHAEL)	2,614	10,40
Tectocepheus velatus juv. (MICHAEL)	1,832	7.29
Belba gracilipes KULCZ.	6	0.02
Oppia spp.	2,589	10.30
Suctobelba subtrigona (OUDEMANS)	645	2.57
Oribella lanceolata MICHAEL	109	0.43
Ceratozetes minimus SELLNICK	2	0.01
Liebstadia similis (MICHAEL)	4	0.02
Oribatella meridionalis BERLESE	1	—
Oribatella calcarata (C. L. KOCH)	4	0.02
Scheloribates pallidulus (C. L. KOCH)	2	0.01
Chamobates schuetzi (OUDEMANS)	33	0.13
Chamobates cuspidatus (MICHAEL)	26	0.10
Oribatei juveniles, *Gen. spec.*	103	0.41
Acari-total	25,127	100.00

Table 8. Number of Acari according to the period

after	6 weeks	3 months	6 months
Mesostigmata	340	359	526
Alliphis siculus	2	67	62
Pergamasus spp.	245	217	340
Uropoda minima	32	40	65
Prostigmata	148	117	85
Bimichaelia diadema	117	79	49
Tarsonemini	265	253	79
Scutacaridae	218	199	45
Acaridiae	479	598	571
Schwiebea spp.	425	386	153
Histiostoma spp.	34	80	413
Oribatei	8,695	6,862	5,750
Steganacarus striculus	1,684	1,351	3,012
Rhysotritia duplicata	304	274	101
Microtritia minima	2,332	1,737	694
Nothrus silvestris	322	348	377
Tectocepheus velatus	2,112	1,401	933
Oppia spp.	1,075	1,199	315
Suctobelba subtrigona	322	239	84

3.2. Acari

The total number of collected Acari and the relative densities are given in Table 7.

HEUNGENS & VAN DAELE (1981) proved that most mite species survive relatively well in an elevated salt concentration (2 g salts l^{-1}; $\pm$ 900 $\mu S\ cm^{-1}$) with the exception, however, of some predator mites.

In the our present tests more elevated doses were also applied. For the best represented Acari the changes in their population densities according to the period are given in Table 8.

In general we can conclude that in time the populations remained relatively stable, with an increase for the Mesostigmata and a decrease for the remaining groups of mites.

(1) Exceptions to the general rule were:
a global increase for *Steganacarus*, which supersedes the other two Phthiracaridae *viz. Rhysotritia* and *Microtritia;*

(2) a pronounced proportional increase of *Histiostoma spp.*, due to the treatments as showed further on;

(3) a pronounced increase of *Alliphis siculus*, due also to certain treatments.

By means of a global analysis of variance it is possible to test the statistical value of the preceding conclusions.

The results of this statistical treatment are summarized in Table 9.

Table 9. The calculated mean squares (M.S.) and the F-values (°) after analysis of variance ($\sqrt[3]{x + 0.125}$-transformation) on the best represented mite numbers

Source of variation		Total	Treatments (T)	Period (P) (Time)	T × P	Residual Error
d.f.		83	6	2	12	63
Alliphis	M.S.	0.3276	1.7709	1.7350	0.3193	0.1470
siculus	F	—	12.05 (**)	11.80 (**)	2.17 (*)	
Pergamasus	M.S.	0.3119	1.3688	0.2083	0.7414	0.1327
spp.	F	—	10.32 (**)	1.57	5.59 (**)	—
Uropoda	M.S.	0.2377	0.8788	0.3284	0.1944	0.1858
minima	F	—	4.73 (**)	1.77	1.05	—
Bimichaelia	M.S.	0.2351	0.7012	0.8542	0.2122	0.1754
diadema	F	—	4.00 (**)	4.87 (**)	1.21	—
Scutacaridae	M.S.	0.3561	0.4110	6.9304	0.2405	0.1642
Gen. spec.	F	—	2.50 (*)	42.21 (**)	1.36	—
Schwieba	M.S.	0.8165	6.5569	4.1389	08310	0.1615
spp.	F	—	40.60 (**)	25.63 (**)	5.15 (**)	—
Histiostoma	M.S.	0.7646	3.3283	2.4975	1.0385	0.4133
spp.	F	—	8.05 (**)	6.04 (**)	2.51 (**)	—
Steganacarus	M.S.	1.1100	6.9161	4.5187	1.9005	0.2983
striculus	F	—	23.19 (**)	15.15 (**)	6.37 (**)	—
Rhysotritia	M.S.	0.4205	2.8379	5.2767	0.1302	0.0914
duplicata	F	—	31.05 (**)	57.83 (**)	1.42	—
Microtritia	M.S.	1.5325	11.1602	23.1954	0.2173	0.1681
minima	F	—	66.37 (**)	137.95 (**)	1.61	—
Nothrus	M.S.	0.4220	3.3622	0.1601	0.5152	0,1458
silvestris	F	—	23.06 (**)	1.10	3.53 (**)	—
Tectocepheus	M.S.	1.3413	7.1473	17.3520	0.8116	0.3810
velatus	F	—	18.76 (**)	45.54 (**)	2.13 (*)	
Oppia spp.	M.S.	0.6822	1.9338	15.2155	0.2347	0.1868
	F	—	10.35 (**)	81.45 (**)	1.26	—
Suctobelba	M.S.	0.4234	1.0295	5.3523	0.3740	0.2187
subtrigona	F	—	4.71 (**)	24.48 (**)	1.71	—

(°) F-table: treatments (T) — 2.25 ($p = 0.05$) 3.12 ($p = 0.01$)
period (P) — 3.15 ($p = 0.05$) 4.98 ($p = 0.01$)
T × P — 1.92 ($p = 0.05$) 2.50 ($p = 0.01$)
(*) (**) significant difference for the confidence levels 95 % and 99 %.

The analysis of variance proves that each mite species (-genus, -family) is affected significantly by at least one of the applied compounds (only for the Scutacaridae in a less significant manner: $p = 0.05$). The period was the most dominant factor for some organisms (Scutacaridae, *Rhysotritia*, *Microtritia*, *Tectocepheus*, *Oppia*, *Suctobelba*); for other organisms however *(Pergamasus, Uropodina, Nothrus)* the factor "time" was insignificant. Compared to the principal factors the interaction "treatment × period" was only of small significance in the variance and in half of the cases there was no significance effect at all.

In Table 10 are given the transformed means according to the treatments and the least significant differences.

Table 10. Transformed mean (*) per 100 ml substrate according to the treatments for best represented mites

	control	nitric acid	citric acid	K-nitrate	Ca-citrate	Ca-hydroxide	K-hydroxide	l.s.d. (0.05) (°)
Alliphis siculus	0.545	0.545	0.632	0.545	0.816	1.590 (++)	0.996 (++)	0.313
Pergamasus spp.	2.421	1.729 (——)	1.953 (——)	1.471 (——)	2.292	2.075 (—)	2.258	0.297
Uropoda minima	1.198	0.847	1.121	0.545 (——)	1.386	1.097	1.093	0.352
Bimichaelia diadema	1.613	1.033 (——)	1.522	0.975 (——)	1.248 (—)	1.426	1.203 (—)	0.342
Scutacaridae *Gen. spec.*	1.946	1.565 (—)	1.573 (—)	1.340 (—)	1.468 (—)	1.602 (—)	1.614 (—)	0.331
Schwiebea spp.	2.251	1.243 (——)	2.516	0.611 (——)	2.553	2.411	1.883 (—)	0.328
Histiostoma spec.	1.043	1.240	0.975	0.770	0.722	2.280 (++)	1.289	0.525
Steganacarus striculus	4.778	3.743 (——)	4.189 (—)	2.589 (——)	4.368	4.332	3.224 (——)	0.446
Rhysotritia duplicata	2.372	2.130	2.143	1.060 (——)	1.922 (——)	1.895 (——)	1.253 (——)	0.247
Microtritia minima	5.013	3.178 (——)	3.921 (——)	2.022 (——)	3.812 (——)	2.714 (——)	3.671 (——)	0.335
Nothrus silvestris	2.931	2.004 (——)	2.523 (—)	1.225 (——)	2.297 (——)	2.098 (——)	1.973 (——)	0.312
Tectocepheus velatus	4.385	3.213 (——)	4.093	1.976 (——)	3.558 (—)—	3.491 (——)	3.226 (——)	0.504
Oppia spp.	3.201	2.740 (—)	3.354	2.282 (——)	2.948	3.356	2.655 (——)	0.353
Suctobelba subtrigona	2.231	1.454 (——)	1.901	1.622 (——)	1.913	1.848 (—)	1.400 (——)	0.382

(*) = $(1/n \sum \sqrt[3]{x + 0.125})$ n = 12 (3 periods × 4 repetitions)
(+) (++) (—) (——) significant more or less than the control for the confidence levels p = 0.05 and p = 0.01
(°) l.s.d. (0.01) = l.s.d. (0.05) × 1.33.

The number of mites per liter after retransformation is given in Table 11. They are reliable estimations of the population density, which are however a little lower than the arithmetic means due to the levelling of the high outliers.

The application of acids, bases and salts in quantities which change the pH, has a pronounced effect on the mite fauna (Tables 10, 11).

All the species studied showed significant changes in their population density.

Most of the treatments resulted in a decrease of the population, although two striking increases of population were also observed (*Alliphis siculus* and *Histiostoma spp.*) probably due to an increase of their prey.

Thus the population of *Alliphis siculus* (predator mite) increased nearly 100 times after application of calcium hydroxide and 20 times after potassium hydroxide. *Alliphis siculus* is a known predator of nematodes, in this way this antagonism can be clearly explained (Heungens 1981). That a smaller number is found in the KOH than in the $Ca(OH)_2$-plots can be easily explained by the higher general toxicity to mites of the KOH treatment.

The *Histiostoma spp.* population also increased from 10 per liter in the control plots to 117 in those with a calcium hydroxide treatment. These small *Histiostoma* take only liquid food rich in microorganisms.

The increase can here be explained by their predation on bacteria, generally present in more dense numbers in soils with higher pH.

Table 11. Average number (*) of the mites per liter substrate

	control	nitric acid	citric acid	K-ni-nitrate	Ca-ci-citrate	Ca-hydro-xide	K-hydro-xide
Alliphis siculus	0.4	0.4	1.3	0.4	4.2	38.9 (++)	8.6 (++)
Pergamasus spp.	141	50 (——)	73 (——)	30 (——)	119	89 (—)	114
Uropoda minima	1.6	0.5	1.3	0.0 (——)	2.5	1.2	1.2
Bimichaelia diadema	40.7	9.8 (——)	34.0	8.0 (——)	18.2 (—)	27.7	16.2 (—)
Scutacaridae *Gen spec.*	72	37 (—)	38 (—)	23 (—)	30 (—)	40 (—)	41 (—)
Schwiebea spp.	112.8	18.0 (——)	158.0	1.0 (——)	165.2	138.9	65.5 (—)
Histiostoma spp.	10.1	17.8	8.0	3.3	1.9	116.5 (++)	18.0
Steganacarus striculus	1,090	523 (——)	734	172 (——)	832	812	334 (——)
Rhysotritia duplicata	132	95	97	11 (——)	70 (——)	67 (——)	18 (——)
Microtritia minima	1,259	320 (——)	602 (——)	81 (——)	553 (——)	511 (——)	189 (——)
Nothrus silvestris—	251	79 (——)	159 (—)	17 (——)	120 (—)	91 (——)	76 (——)
Tectocepheus velatus	842	330 (——)	684	76 (——)	449 (——)	424 (——)	335 (——)
Oppia spp.	327	205 (—)	376	118 (——)	255	377	186 (——)
Suctobelba subtrigona	110	30 (——)	68	41 (——)	69	62 (—)	26 (——)

(*) Period: mean between 6 weeks, 3 and 6 months after treatment; After retransformation and biometric calculation.

(+) (—) (++) (——) significant more or less than the control for $p = 0.05$ and $p = 0.01$.

Further, it can be observed that only in the case of *Alliphis* and *Histiostoma* none of the treatments resulted in a population decrease. It could then be accepted that the population increase is due to their tolerance to the applied compounds together with the increased food possibilities (predation) and the lower food competition.

Besides these population increases many decreases were noted. Of the applied compounds potassium nitrate was pronouncedly the most toxic to soil mites, followed by nitric acid and potassium hydroxide.

Our results prove that the conductivity or the osmotic pressure caused by the compound used had a more population decreasing effect than the corresponding pH. However the mite mortality was less pronounced than the enchytraeid mortality (HEUNGENS 1984).

In general the population differences between the treatments were moderate. Exceptions were: *Pergamasus* (KNO_3), *Bimichaelia* (KNO_3, HNO_3), *Schwiebea* (KNO_3, HNO_3), *Steganacarus* (KNO_3), *Rhysotritia* (KNO_3, KOH), *Microtritia* (KNO_3, KOH), *Nothrus* (KNO_3) *Tectocepheus* (KNO_3) and *Suctobelba* (HNO_3, KOH).

Of the applied compounds the KNO_3-dose was for mites the most toxic. Eighty-seven percent of the Oribatei and 83% of the non-Oribatei species were destroyed (see Table 11). The second most toxic compound for the Oribatei (71% destroyed) was KOH and for the non-Oribatei it was HNO_3 (65% destroyed).

The graphs (Fig. 2) illustrate the variations in the population densities according to the treatments used.

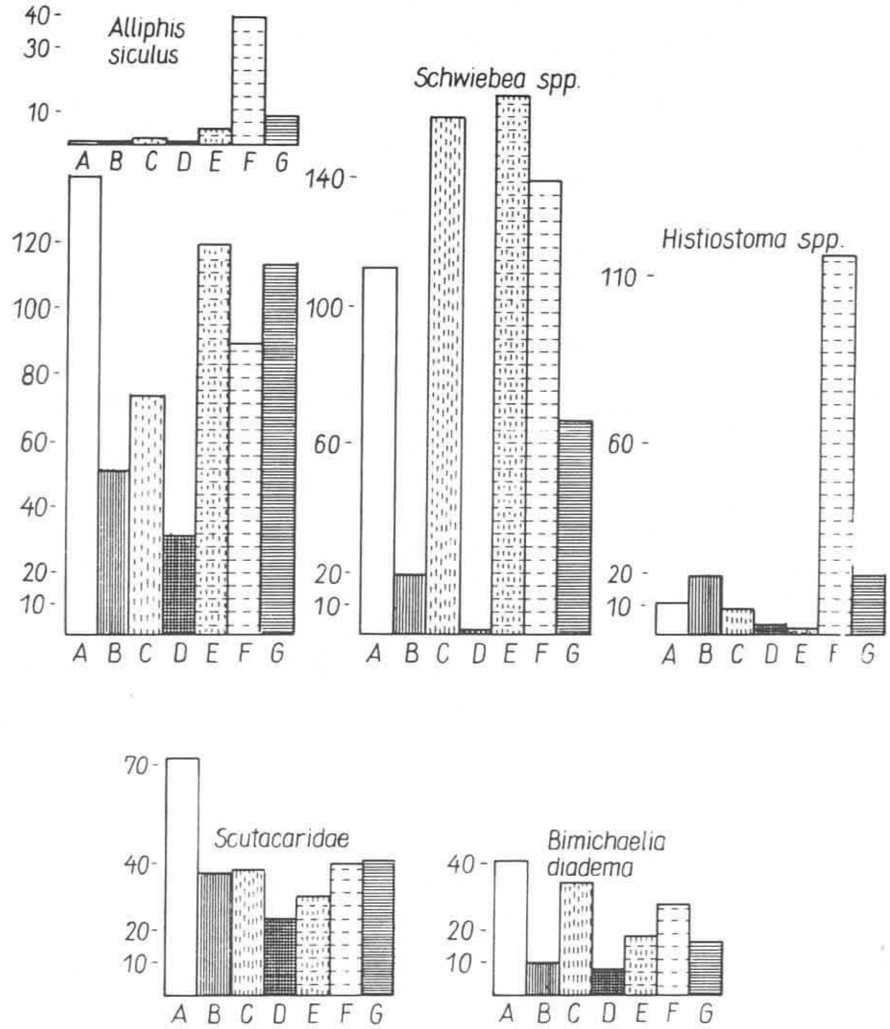
Alliphis siculus
Schwiebea spp.
Histiostoma spp.
Scutacaridae
Bimichaelia diadema
A B C D E F G

Fig. 2a

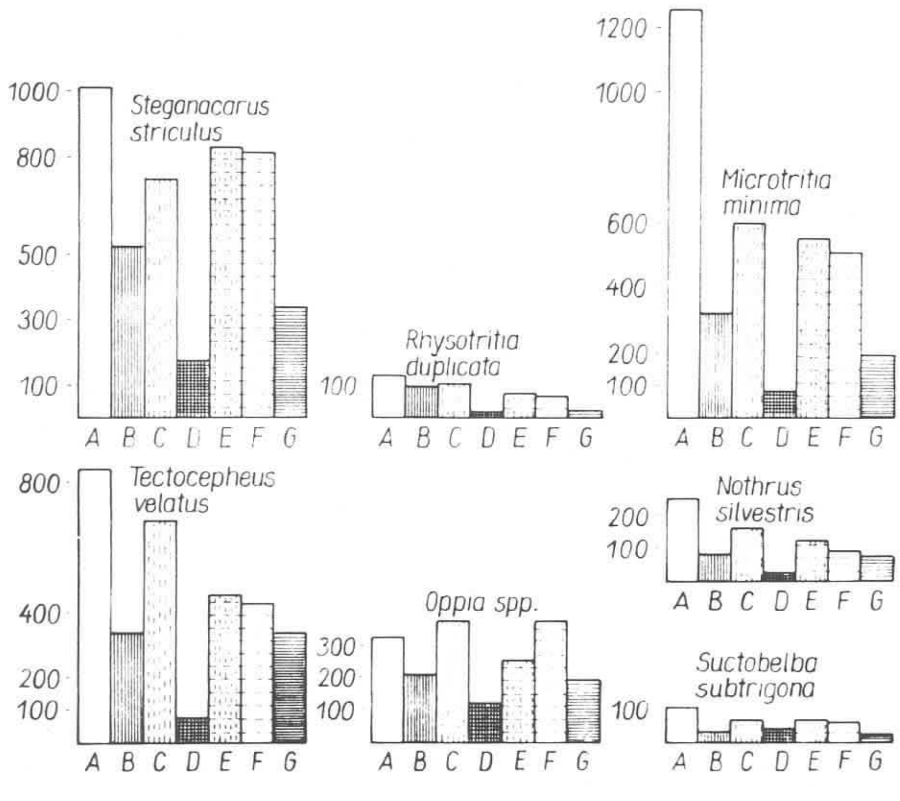
Steganacarus striculus
Rhysotritia duplicata
Microtritia minima
Tectocepheus velatus
Oppia spp.
Nothrus silvestris
Suctobelba subtrigona
A B C D E F G

Fig. 2b

4. Discussion

Hutson (1978) also studied the influence of the pH and the salt content on Collembola in laboratory tests. The collembola were kept on a substrate of plaster of Paris and charcoal. Thus their medium was different from ours. In Hutson's experiments, the fecundity was highest at pH 5.2 for *Tullbergia krausbaueri* and *Isotoma notabilis*. The fecundity of *Proisotoma minuta* was highest at pH 7.2.

In our experiments we noted a 400% population increase in the KOH-plots, but as the pH of the KOH- and $Ca(OH)_2$-plots were not really different, we are unable to explain this increase due to the pH alone.

Hågvar & Abrahamsen (1977) stated that springtails in some experiments increased in acidified plots. Bååth *et al.* (1980) obtained increased Collembola numbers after acidification of the pine litter, but the increase was entirely due to an increase in abundance of *Tullbergia krausbaueri*. To the contrary our experiment showed a decrease in numbers in the acidified plots for *T. krausbaueri*. In the experiments of Bååth *et al.* (1980) the pH of the soil was only slightly lowered by the acid treatment, while liming increased the pH considerably. Nevertheless the liming presented no marked effect on soil organisms.

Hågvar & Abrahamsen (1977) found no differences in the abundance of mites in acidified plots in pine litter. In the experiments of Bååth *et al.* (1980) the total number of mites was unchanged in acidified plots, but *Trachytes sp.* and *Oppia obsoleta* decreased. Liming had no marked effect.

Żyromska-Rudzka (1979) stated that Scutacaridae are extremely sensitive to fertilization of a meadow with NPK doses. In our experiments the Scutacaridae population also decreased after all the treatments, but the decrease was rather slight (ca. 50%) compared with the results obtained by Żyromska-Rudzka. In our previous experiment with a NPK-fertilizer even at 2 g per liter of pine litter we did not note a decrease (Heungens & van Daele 1981).

5. Conclusions

The tests prove that in general Collembola are more sensitive to a low than to a high pH. These results are in opposition to these obtained by the before mentioned authors, without doubt attributable to other pH-limits and other acidifying compounds.

The pronounced increase at a higher pH of the *Proisotoma minuta* population seems to be more general. Its mechanism however cannot yet be completely explained.

From the literature on mites one gets the impression that soil mites in general are not influenced much by different pH levels.

This could be the case in natural environments where there is little change in pH levels.

Our tests prove that the application of acids, bases and salts in substantial quantities has a pronounced effect on the mite fauna.

Fig. 2a. The average number of the mites (non-Oribatei) per liter of substrate according to the treatments.

A = Control
B = Nitric acid
C = Citric acid
D = Potassium nitrate
E = Calcium citrate
F = Calcium hydroxide
G = Potassium hydroxide

Erratum: The missing name at the top of the left diagram (middle row) reads as *Pergamasus spp.*

Fig. 2b. The average number of the mites (Oribatei) per liter of substrate according to the treatments.

A = Control
B = Nitric acid
C = Citric acid
D = Potassium nitrate
E = Calcium citrate
F = Calcium hydroxide
G = Potassium hydroxide

However the conductivity or the osmotic pressure due to the compounds used in our experiments had a more population decreasing effect than the corresponding pH.

The entire assemblage of the dominant species showed significant changes in their population densities. Although most of the treatments resulted in a decrease of the population, striking increases in some species also occurred.

6. Résumé

L'influence de quelpues acides, bases et sels sur les populations d'Acariens et de Collemboles d'une litière de pin.

L'influence du pH sur les populations d'Acariens et de Collemboles d'une litière de pin a été étudiée. Dans ce but les produits suivants ont été appliqués aux substrats: acide citrique et nitrique, hydroxyde de potasse et de calcium, nitrate de potasse et citrate de calcium.

Les valeurs pH les plus extrèmes au cours de l'essai étaient de 3,3 et de 7,3.

Les Collemboles et Acariens ont été échantillonnés après $1^1/_2$, 3 et 6 mois. Au total 5310 Collemboles (11 espèces) et 25.127 Acariens (au moins 68 espèces) ont été observés.

L'influence de la date d'échantillonnage sur les populations de Collemboles est plus prononcée que celle des traitements. Les Collemboles les mieux représentés sont plus sensibles à un pH acide qu'a un pH neutre; comparé au témoin l'espèce dominante *Proisotoma minuta* présente une augmentation de 400% dans les traitements au KOH. La période d'échantillonnage a également une influence notable sur les Acariens, mais dans la moitié des cas les produits changeant le pH ont une influence encore plus prononcée.

La plupart des traitements font baisser la population, bien que deux remarquables augmentations des populations sont également observées, notamment pour *Alliphis siculus* et *Histiostoma spp.* dans le traitement à l'hydroxyde de calcium. Ceçi est probablement du à une augmentation du nombre de leurs proies. Parmi les produits appliqués le KNO_3 est de loin le plus toxique pour les Acariens édaphiques, suivi par l'HNO_3 et le KOH.

Les résultats démontrent également que la conductivité, ou la pression osmotique, occasionnée par les produits appliqués, font baisser la population plus fortement que l'effet du pH correspondant.

7. References

BÅÅTH, E., B. BERG, U. LOHM, B. LUNDGREN, H. LUNDKVIST, T. ROSSWALL, B. SÖDERSTRÖM, & A. WIREN, 1980. Effects of experimental acidification and liming on soil organisms and decomposition in a Scots pine forest. Pedobiologia **20** (2), 85—100.

HÅGVAR, S., & G. ABRAHAMSEN, 1977. Acidification experiments in conifer forest. 5. Studies on the soil fauna. Acid Precipitation — Effects on Forest and Fish — Project (Norway) Internal Report **32**, 1—47.

HEUNGENS, A., O. VERDONCK, & A. ROOS, 1975. Considérations sur la conductivité et la salinité des substrats dans la culture des plantes ornamentales. Revue de l'Agriculture **28** (2), 359—366.

— 1980. The influence of salt concentration on the enchytraeid population in pine litter. Pedobiologia **20**, 154—159.

— 1981. Nematode population fluctuations in pine litter after treatment with pH changing compounds. Meded. Fac. Landbouwwet. Rijksuniv. Gent, **46** (4), 1267—1281.

— 1984. The influence of some acids, bases and salts on an enchytraeid population of a pine litter substrate. Pedobiologia **26**, 137—141.

— & E. VAN DAELE, 1981. The influence of salt concentration on mite population in pine litter. Pedobiologia **22**, 39—51.

HUTSON, B. R., 1978. Influence of pH, temperature and salinity on the fecundity and longevity of four species of Collembola. Pedobiologia **18** (3), 163—179.

ŻYROMSKA-RUDZKA, H., 1979. Disappearance of Scutacaridae (Acarina) due to high concentrations of mineral nutrients in a meadow. Pedobiologia **19** (1), 9—17.

Address of the authors: Dr. ir. A. HEUNGENS (corresponding author) and ir. E. VAN DAELE, Fakulteit van de Landbouwwetenschappen, Rijksuniversiteit Gent, Coupure Links 653, B-9000 Gent, Belgium.

Synopsis: *Original scientific paper*

HEUNGENS, A., & E. VAN DAELE, 1984. The influence of some acids, bases and salts on the mite and collembola population of a pine litter substrate. Pedobiologia **27**, 299—311.

The influence of the pH on the mite and Collembola population in pine litter was studied. For that purpose citric and nitric acid, potassium and calcium hydroxide and the salts potassium nitrate and calcium citrate were applied.

The most extreme pH-ranges during the experiment were 3.3. and 7.3.

The Collembola and mites were sampled after 1.5, 3 and 6 months. A total of 5 310 Collembola and 25 127 mites were counted, comprising 11 Collembola species and at least 68 mite species.

The sampling period had a more pronounced effect on the Collembola population than the treatments. The most represented Collembola were more sensitive to a low than to a high pH, and compared with the control there was for the dominant species *Proisotoma minuta* a 400% population increase with the KOH treatment.

The sampling period had also a striking influence on the mites but in one-half of the cases the pH-changing compounds had a stronger impact. Most of the treatments resulted in a decrease of the populations. although two very striking increases of populations were also observed; namely, *Alliphis siculus* and *Histiostoma spp.* in the calcium hydroxide plots, probably due to an increase of their prey. Of the applied compounds used KNO_3 was pronouncedly the most toxic to soil mites, followed by HNO_3 and KOH.

Our results further indicated that the conductivity or the osmotic pressure changes due to the compounds used had a more population decreasing effect than the corresponding pH.
Key words: Collembola, Acari, pine litter, pH, salt, fertilizer, electrical conductivity, osmotic pressure.

Pedobiologia
Verlag: VEB Gustav Fischer Verlag Jena, DDR - 6900 Jena, Villengang 2, Telefon 27332.
Verantwortlich für die Redaktion: Dr. E. von Törne, DDR - 1300 Eberswalde-Finow 1, Rudolf-Breitscheid-Straße 48.
Redaktioneller Mitarbeiter im Verlag: Margarete Kaufmann.
Veröffentlicht unter der Lizenznummer 1074 des Presseamtes beim Vorsitzenden des Ministerrates der Deutschen Demokratischen Republik.
Satz, Druck und Buchbinderei: Druckerei „Magnus Poser" Jena, Betrieb des Graphischen Großbetriebes INTERDRUCK Leipzig, Betrieb der ausgezeichneten Qualitätsarbeit.

Printed in the German Democratic Republic.
Artikel-Nr. (EDV) 66215.
Erscheinungsweise: 1984 12mal, Heftpreis: DDR 18,70 M.